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GEOGRAPHICAL DISTRIBUTION OF THE MARINE ALGÆ[1]

In connection with some work I am attempting along the line of geographical distribution, it has become desirable to make some sort of a survey of the entire literature of the marine algæ, to classify it and to note the influence of various writers in developing the different lines of geographical study. The progress of the knowledge of the marine algæ has been slow in comparison with that of most other groups and the progress of our knowledge of the geographical distribution has been slower still. Much of this is due to the comparatively limited access to living material, the difficulties of collection, and the lack of any extensive economic value.

In attempting to arrange the literature, as indicating the progress of thought and development, it has seemed best to separate the lines of work formally, and somewhat arbitrarily, into several more or less distinct, yet necessarily overlapping and intertwined groups of subjects. The subjects finally selected as bearing either directly or secondarily on geographical distribution are five, viz., taxonomy, morphology and development, floristics, physiology and geographical distribution. It is, of necessity, an impossible matter to segregate all the literature and arrange it definitely under one or another of these groups. Certain writers have written along two or more of these lines and in the later literature, particularly, several lines of thought and

[1] Address of the vice-president and chairman of Section G, Botany, American Association for the Advancement of Science, New York, December 27, 1916.

research are often found in combination. Nevertheless, both writers and works, as a rule, follow a main trend and may be arranged under one or another of the principal subjects, although important contributions under a different subject may also be included. Each of the subjects, in turn, may be divided into periods according to the principal influence at work and the progress along a special line of development. One period naturally passes over into another, the way being prepared by those writers whose work may be termed anticipatory and the inception of a new period being marked by some writer, or group of writers, whose advance is more pronounced and whose innovations have had the greatest influence. In taxonomic lines, the beginnings are to be found in the earliest writers, both botanical and non-botanical, and the progress in the study of the marine algæ was necessarily slow until the study of more and more of the more complex plants had pointed the way and, to some extent at least, the methods.

Naturally the earlier work on the marine algæ, as on higher plants, was taxonomic, particularly descriptive. In the earlier period mere mention was made in general, but Morison, Ray, Hudson, Dillenius and Linnæus, for example, laid the foundations upon which Goodenough and Woodward, Gmelin, Turner, Esper, Poiret, De Candolle and others built more solidly. Gmelin (in 1768) published the first book on marine algæ, entitling it "Historia Fucorum." In the latter portion of this first period Roth and Stackhouse prepared for the coming of a more logical treatment, especially as to genera. The older method divided the species of algæ between such polymorphic and indefinite genera as *Fucus, Ulva, Conferva, Byssus* and *Tremella.* Roth and Stackhouse added a few new ones, but these are also mostly of extensive application and of indefinite character.

The second period of taxonomic progress dates from 1813, when J. V. Lamouroux published his "Essai sur les genres de la famille de Thassiophytes non articulées." Lamouroux practically instituted genera in very much the modern sense and laid the foundation for future work. Henceforth both the general morphology and the character of the fructification were taken into account in taxonomic work. Besides Lamouroux Bory de Saint Vincent, C. A. Agardh and Lyngbye were responsible for advance in the earlier part of this second taxonomic period. They were succeeded by Greville, Montagne, Decaisne, J. G. Agardh, J. D. Hooker, W. H. Harvey, Kützing, J. E. Areschoug, Ardissone, Zanardini, Ruprecht and others.

The latter part of the second taxonomic period is merged with and came under the influence of a more careful morphologic and histologic study and a closer attention to the structure and development of the organs of fructification. Kützing did much to promote this in his "Phycologia Generalis" (1843) and his "Tabulæ Phycologicæ" (1845–1869). Naegeli, Cramer, Zanardini and others assisted in the same direction. These works mark the passing over into the third distinct taxonomic period which may be said to have begun with Thuret and Bornet and which has continued down to our own times. Its earlier inquiry into the nature of the reproductive bodies dates from Thuret's classic researches on the zoospores and antheridia of the algæ (1845–1855). This was continued into the discoveries as to the modes of development of the cystocarp in the red algæ and all came as a culmination of the similar work by Pringsheim, Naegeli and others. The magnificent "Notes Algologiques" (1876, 1880) and "Etudes Phycologiques" (1878) will long remain as examples of the finest contributions along these various lines of histolog-

ical and developmental researches. The progress along this line has led to other studies of histological and developmental details. These in turn have led up to the present condition, when it seems desirable to make a new and more detailed study of all species, but especially of those credited with a wide geographical distribution or with great variability.

The third and latest period of taxonomic development has resulted in a newer view of specific limitation, in other words, has resulted in specific segregation being carried to a much greater degree than hitherto, yet seemingly not beyond reasonable limits. The results may be seen from Kjellman's treatment of *Galaxaura* (1900), Falkenberg's treatment of the *Rhodomelaceæ* (1901), A. and E. Gepp's treatment of the *Codiaceæ* (1911), Sauvageau's treatment of the *Sphacelariaceæ* (1900–1914), Howe's treatment of *Halimeda* and other genera (1905–1914) as well as of other groups, Foslie's treatment of the crustaceous corallines, Boergesen's treatment of the algæ of the Danish West Indies (1913–1916), my own treatment of *Scinaia* (1914), and others. In my own study of various genera of the red algæ, both from the point of view of morphological differences and of geographical distribution, it is necessary to more carefully distinguish and separate the true species in the case of many aggregates and to scrutinize very carefully those species credited with extended or widely discontinuous distribution. The results throw a much clearer light on certain seemingly troublesome points of geographical distribution, both climatic and topographical.

The anatomical and histological aspects of the morphology of the marine algæ were earlier treated of in connection with the taxonomy. In the first period of taxonomy, the study of the structure both of the vegetative and reproductive portions was slight, although some progress was made through Reaumur (1711), Stackhouse, Turner and others. In the second taxonomic period, Lamouroux gave a great impetus to the study of structure and the distinctions between the different methods of fructification and towards the last of this second period the knowledge of structure was placed on a fairly firm basis.

It was during the third taxonomic period that the study of morphology may really be said to have originated as a separate subject and much of the credit for properly emphasizing it came from Thuret, both by his own publications and by those in connection with Bornet. Since then many special papers dealing with the adult or developmental morphology have been published. Cytological work, too, has been carried on to a considerable extent. The cell membranes have been studied by Correns and others; the chromatophores by Schmitz and his successors; various cell contents, including the plasma massing in the cells of iridescent marine algæ by Berthold and others. The study of the nucleus and its division has engaged the attention of many investigators from Schmitz (1879) through Fairchild, Swingle, Farmer, Strasburger, Osterhout, Williams, Wille, B. M. Davis and Oltmanns. Yamanouchi and Svedelius, in particular, have investigated the chromosome number in connection with the alternation of generations of red algæ. The morphology, both gross and minute, of holdfasts, vegetative and reproductive organs, have been, and still are being, given most careful attention, in connection with taxonomic, physiological and ecological investigations.

While most attention has been turned towards the morphology and development of the marine algæ, their special physiology has received some attention. By far the greater portion, however, remains to be done. It is impossible to more than call

attention to some main lines of work in this communication. The physiological effects of the pigments by Gaidukov, Rosanoff, Reinke, Schütt and Kylin; metabolic activities of various sorts such as those dealt with by Loew and Bokorny, by Hansen, Wille, Arber, Artari and a host of other investigators; the physiology of reproductive processes by Klebs; the method of production of lime incrustations by Lütgeb; the influence of external surroundings by Oltmanns. The physiologico-anatomical researches of Wille and his pupils may be mentioned here. The influence of light, temperature, specific gravity of the sea water, chemical stimuli, etc., have been touched upon by various authors, but these important physiological bases for explaining the facts of geographical distribution and particularly of ecological distribution are still most obscure.

To deal with the geographical distribution of plants it must be recognized that there are several methods of approach, and in dealing with the geographical distribution of the marine algæ, the methods of approach are, in general, the same as those used in dealing with other plants. The first efforts are floristic and usually largely taxonomic. Species are defined more and more accurately and floras are made out for larger or smaller coast lines. Then comes a comparison of floras with one another as to percentages of common or differing species. Cosmopolitan or widespread species are discussed, as are also endemic species, or at least species of more restricted areas and finally the comparison of floras leads to a discussion of the relation of floras as to origin, spread, etc.

Less has been done in the floristics of marine algæ than in that of terrestrial plants. There are comparatively few floras, although many lists have been published. One of the earliest marine floras or lists was that of Goodenough and Woodward for the British Fuci (1797) in which only 72 species were described. This was followed by that of Turner (1802), who enumerated and described 78 species. These included only the species of *Fucus* as then understood. Greville in his Algæ Brittanicæ (1830) greatly increased the number and Harvey in the two editions of his Manual (1841 and 1849) as well as in the Phycologia Brittanica (1846–1851) brought the number up to 388, while Holmes and Batters in their lists of British Algæ (1890, 1891) enumerate 557 species. C. A. Agardh's Synopsis Algarum Scandinaviæ (1817) is another early algal flora as is also Lyngbye's "Tentamen Hydrophytologicæ Danicæ" (1819). More modern is the "Algues Marines du Cherbourg" (1864) of A. Le Jolis and one which has had great influence as a model. One of the earliest accounts to contain a direct comparison between a particular marine flora and other marine floras is Farlow's "Marine Algæ of New England" (1881), in which the comparison is made in the percentage of species between the various subdivisions of the New England coast and also between them and the flora of various parts of Europe, of the Arctic Regions and of the Pacific Coast of North America. Martens (1866) had previously made such a comparison in detailed list between various divisions of the tropical marine flora. Other writers have attempted to classify floras as to their content of species common to or characteristic of other regions as well as those confined to their own region. The most formally floristic papers as to geographical distribution of marine algæ are those of George Murray on "A Comparison of the Marine Floras of the Warm Atlantic, Indian Ocean and the Cape of Good Hope" (1894) and of George Murray and E. S. Barton on "A Comparison of the Arctic and Antarctic Marine Floras" (1895). These papers deal with the percentage of endemic species and

of those common to two or more subdivisions and lay particular stress on the relative number of species to the genus in the various geographical divisions or subdivisions.

The results of this purely floristic work on the marine algæ has been, just as has happened more extensively in phænogamic floristics, the separation of floras more or less distinctly marked off from one another and in some cases the discovery of definite demarcation points. As illustrations of this may be mentioned the following: the Arctic and Mediterranean marine floras were readily understood, but the intermediate floras were not distinguished, nor were there any sharp points or districts of demarcation discovered. The marine flora of the Cape of Good Hope region has always been recognized as very distinct, but the exact limits have never been determined. On the eastern coast of North America, on the contrary, and especially on the coast of New England, not only was the northern flora recognized as different from that of Long Island Sound and southward, but also the Cape Cod Peninsula was indicated as the region of demarcation between the two. This was first mentioned by W. H. Harvey in the first part of the "Nereis Boreali-Americana" (1851). Harvey divides the east coast of North America into 4 divisions, viz., "First, the coast north of Cape Cod, extending probably to Greenland; second, Long Island Sound, including under this head New York Harbor and the sands of New Jersey; third, Cape Hatteras to Cape Florida;" and "fourth, Florida Keys and shores of the Mexican Gulf." This dividing up of the marine flora of the eastern coast of North America is the first division of any definiteness for that of any extended coast and corresponds fairly closely to the zones of the marine flora into which my own investigations indicate it should be divided. Harvey's statements in the "Nereis Boreali-Americana" result from his ideas formulated in the second edition of his "Manual of the British Marine Algæ" and are a direct application of the earlier ideas of Lamouroux (1825, 1826). Along with the separation of floras is a comparison, as to similar latitudes and isothermal lines, between the east coast of North America and the coasts of Europe, but these isotherms are lines of mean annual temperature and likewise are those of the air, but not of the water, indeed for application to land floras, and not affecting, as a whole, at least, the marine flora. This work of Harvey was the first detailed attempt to associate floristic methods with the factors which control climatic distribution.

Later developments of the floristic idea are to be found in Kjellman's work, especially in the "Algæ of the Arctic Sea" (1883) and in the works of Simmons (1897) and of Börgesen and Jönsson (1905) on the marine flora of the Faeroes and the North Atlantic. The Baltic Sea was studied as to its marine flora by Reinke (1889), Svedelius (1901), and Kylin (1906, 1907), that of New England by Farlow (1881) and Collins (1900), that of Iceland by Jönsson (1912), tropical floras of the Indian and Pacific Oceans by Schmitz (1896) and Schroeder (1902), and the antarctic floras by Gain (1912). All these works have been along the same general lines.

To sum up the results of the floristic work, general climatic regions have been set off and distinguished from one another, methods of and agents in dispersal have been discussed, demarcation points between floras have been determined, centers of distribution have been emphasized, and barriers to dispersal have been surmised. All these lead toward the discussion of climatic distribution and to some extent toward that of topographical distribution or ecology. Yet these are all more floristic in style and

point of view than from the standpoint of geographical distribution in relation to definite factors controlling it.

The idea of geography as applied to plant life, while present in indefinite form in the treatises of the Greek period, came as a revolutionary idea to the German Fathers and their immediate successors. It was Alexander von Humboldt, however, who, early in the nineteenth century, gave the first real impulse to the idea of the study of the geography of plants (1805) and the climatic conditions, climatic zones and altitudinal zones which are to be associated with, and to be taken account of in connection with it. It was J. V. Lamouroux, however, who first formulated the outline of topics connected with the distribution of "Hydrophytes" (marine algæ) in 1825 and 1826. Lamouroux had for his models the works of von Humboldt, A. P. De Candolle and Robert Brown on "Aerophytes." It is of interest to notice the topics brought forward by Lamouroux. In the first place, the basis for his study, as he states, consists of some 1,200 species of his own collections and those of the various botanists of Paris, and including specimens collected in many voyages to distant parts of the world. He touches upon species which are, in a sense, cosmopolitan and speaks of the Ulvaceæ or sea lettuce family, as being distributed from the poles to the tropics. This is particularly in connection with the temperature factor and he remarks that the number of species is greater in the temperate zones than in the very cold or very warm zones. In treating of the distribution of families, he makes the point that because of the configuration of coast lines, their distribution from a center is linear rather than radiating as in land plants. He mentions seasonal temperature effects in that the period of higher temperature in any locality shows the greater number of species. He also suggests that possibly the depth relation to distribution is the same as the altitudinal relation to land floras and that there may possibly be expected an arctic or frigid marine flora in the depths of tropical waters, as a frigid land flora is found on high peaks in warm zones. Lamouroux takes up the influence of light, of the aeration of the water and of the plant exposed more or less often and more or less completely by the ebb and flow of the tides. The substratum receives some attention from Lamouroux and also a considerable attention is given to the distribution of the particular divisions and families. Altogether Lamouroux has treated of a considerable number of facts and factors underlying even the more modern consideration of the subject. Greville (1830) and W. H. Harvey (1849, 1851), as has already been stated, have followed Lamouroux and have treated of the geographical relationships of the various floras, but chiefly from the point of view of floristics. Lamouroux and Harvey laid the chief emphasis on general climatic factors, of which temperature is by far of widest effect and importance, and this view was followed by the later writers, who associated factors with their floristic treatment. A new impetus was given the study of climatic distribution by Kjellmann's various papers, particularly by "The Algæ of the Arctic Sea" and the later subdivisions of the Polar Sea. The discussion of the marine floras of the North Atlantic at the hands of Reinke, Simmons, Boergesen and Jönsson simply emphasizes the importance of this climatic factor or sets of factors.

Before leaving this more general treatment, it may be well to speak of Piccone's work (1883) as the only general treatise, other than that of Lamouroux, on the geographical distribution of the marine algæ. Piccone treats of the general features of an algal flora and the general conditions, such as the substratum, both as to physical and

chemical aspects as well as the modes of attachment to and the various methods of aggregation of the algæ on it. He considers also the aspects of chemical composition and variation in salinity of the sea water, as well as its purity, its gas content, its density and its color. There follows a discussion of the influence of the temperature of the water, of the influence of light, of color of the water, of methods of dispersal by currents and by fishes, of the nature of spores, etc. Finally the general organization of the plants themselves is dealt with.

Under the head of climatic distribution and with the controlling factor of temperature in mind, may be mentioned my own papers on this subject in 1893, 1903 and 1914, respectively, where there is an attempt made to outline certain climatic zones depending primarily upon the mean temperature of the surface waters. In these papers I have treated in a general and preliminary way of temperature zones, 5° C. apart, as to surface waters and mean maximum temperature. I have also briefly touched upon the invasions of these zones at seasons of other temperatures, particularly at the mean minima, by species from other zones. These invasions account for much of the seeming disturbances of uniformity and exclusiveness of flora. I am now prepared to account for other invasions due to the raising of temperature of the algæ in tidal belts and in shallow areas, such as salt lagoons and estuaries through the temperature of the air. Through these factors practically all invasions or overlappings from one zone into another, may, as it now seems to me, be explained.

Turning from the papers which are generally floristic or which deal only with the general climatic factors, there are certain papers dealing with the topographical or ecological distribution. While Lamouroux hinted at certain features such as the influence of aeration in the tidal belts and the influence of the substratum, the first papers to deal with topographical features of distribution for marine algæ were those of J. G. Agardh (1836) and Oersted (1844). Both divided the shore belts of the Danish and southwest Swedish coasts into three regions, the uppermost characterized by a predominance of the green algæ, the middle by the predominance of brown algæ, and the lowermost by that of the red algæ. Oersted, however, was the first to attribute this division into regions to a definite influence, viz., to the light as to depth penetration and as to color. Kjellman, later and in several papers, also divides the shores generally into three "regions," the littoral, the sublittoral and the elittoral. He also developed the idea of algal formations, or, as they are more properly called, of "associations." In both these segregations, Kjellman is followed by most later writers.

Rosenvinge for Greenland, Boergesen for the Faeroes, Kylin for the western coast of Sweden and Jönsson for Iceland have applied and extended the ideas of Kjellman as to topographical units and the factors controlling them, as well as for factors of climatic importance. Jönsson (1912) has given a particularly complete and satisfactory outline and discussion.

Schimper, Warming and Clements have given classifications of the marine, as well as the fresh-water algæ, distinguishing the plankton or swimming forms from the benthos, or attached forms, and, in distinguishing the benthos formations according to the substratum, viz., as to sand or rock and in making even farther distinctions.

Two papers of recent date contain data and observations of great importance in topographical distribution of the marine algæ. One of these is the contribution of B. M. Davis (1913) to the "Biological Survey of the Waters of Woods Hole and Vicinity," while the other is the paper of K.

Yendo (1914) "On the Cultivation of Seaweeds with Special Accounts of their Ecology." In each of these papers attention is called to ecological factors modifying or illustrating the workings of general factors of distribution as well as those concerned in special topographical distribution.

To sum up the general results and to attempt to determine the general subdivisions of the coast lines to satisfy all requirements of geographical distribution, the following seems to be a reasonable, although tentative, arrangement, both as to climatic and as to topographical divisions.

CLIMATIC

I. *Zones,* regulated by temperature of the warmer months, especially to be determined by the mean summer temperatures or in practise by the isotheral lines at intervals of 5° C.;

II. *Regions,* purely geographic segregations under zones;

III. *Provinces,* subdivisions of regions according to mean winter temperatures, in practise by isocrymes, 5° apart or less;

IV. *Districts,* subdivisions under provinces according to geographical remoteness and varying physical conditions of a general nature;

TOPOGRAPHICAL

V. *Formations,* aggregations of algæ of same general form, depending particularly upon substratum;

VI. *Associations,* aggregations of algæ depending for general likeness of plant form, etc., on depth (belts), salinity, light, aeration, etc., generally characterized by the predominance of a single, or at most, of a few species.

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THE CARNEGIE INSTITUTION OF WASHINGTON AND SCIENTIFIC RESEARCH[1]

Numerous references have been made in preceding reports to the growing realization of the world at large that the methods of science are the most effective methods thus far developed for the advancement of learning and for the mitigation of the consequences of the inexorable "laws of nature" which condition existence on our planet. Reference has been made likewise to the contemporary rise and progress of other research establishments and to the introduction of investigation as an economic adjunct to industrial enterprises. These manifestations of popular approval and confidence continue to be among the most noteworthy signs of the times. Indeed, it is plain that we are now witnessing a remarkably rapid evolution of public understanding of the meaning and the value of research. This has been greatly intensified and accelerated by the European war, whose sinister aspects appear to be relieved in some degree by the prospects of an awakened realization of the availability of better methods than those of warfare for settling international disputes, of better methods than those now commonly applied in the government of states, and of better methods in education, in sanitation, in industry, and in biological economy generally. The European war has emphasized to a degree not hitherto attained in the world's history the perils of ignorance, of government by assumed divine right, and of that sort of diplomacy which shades off by insensible degrees into duplicity; and it has emphasized equally clearly the necessity for rational investigation of and progressive reforms in all national affairs.

How the details of this evolution, in which the institution must participate, will

[1] From the report of the president for 1916.

work themselves out is impossible to predict except in general terms. It may be safely inferred, however, from the history of similar developments, that this one will proceed much more slowly and with much more difficulty than many enthusiastic optimists anticipate. Evolution is, in general, a secular process and goes on with a leisurely disregard of individuals. It may be safely inferred also that many of the numerous fallacies which have beset the institution during the brief interval of its existence will recur again and again in the rise of similar organizations, while fallacies of a more troublesome type are likely to beset the introduction of the methods and the results of research in governmental affairs. It is in the latter affairs that the most stubborn opposition to progress is usually met, since there exist, as a rule, in such affairs no adequately developed relations of reciprocity between those best qualified to suggest and to formulate improvements and those who control the machinery for their applications. Such improvements can be secured only by overcoming a stolid adherence to precedent as well as the reluctance of rational conservatism. Thus it happens in governmental affairs that the most incongruous ideas often coexist, as is well shown by the contemporary adoption of the most advanced principles of sanitation in certain European countries which are still dominated by medieval theories of the functions of a state. To cite another illustration readily understood and verifiable, it is an anomalous fact that the United States government exacts no professional requirements for the direction of its highly technical affairs except in a single branch of its service, namely, the legal. And in line with this glaring national deficiency it is notorious that the fiat of an executive can make an astronomer, a geodesist, or a biologist out of a man whose works are unknown in the annals of the science of which he becomes the ex-officio representative. We hear much also in these days of the "mobilization of genius" in the interests of national preparedness for commercial and industrial competition, if not for the more serious exigencies of national defense; but it is to be feared that this mobilization means fruitless attempts to utilize aberrant types of mind, or perhaps the employment of men of talent under the direction of those whose competency for leadership is admitted, if at all, only in quite other fields of activity than those here considered. In the meantime, it is plain enough, in the light of current events, that any nation whose governors mistake necromancy for science, confound invention with investigation, or fail to utilize effectively available and advancing knowledge, is in danger of humiliation in peaceful international competition if not in danger of extinction in international conflict.

Much, perhaps too much, has been said in preceding reports concerning the maxims and the principles which should be observed on the administrative side in the conduct of research. To a great extent these maxims and principles are the same as those developed in the common experience of the race; but to a greater extent they are derived from the more concrete and the more sharply defined experience developed in the evolution of the older sciences. All experience teaches that effective research depends on painstaking labor, arduously, patiently and persistently applied; while all science teaches that research is effective only in those regions wherein something like demonstration can be attained. If investigations can not be well done they are of little worth; if nothing can be proved they are of still less worth, or at best only of negative value. But obvious as these truisms are when stated by themselves, they have been con-

tradicted daily in the plexus of events which make up what our successors will call the history, recorded and unrecorded, of the institution. Thus it has been suggested not infrequently that promising researches be suspended in order that equally or less promising researches might be taken up; and it has happened that proposals to abolish departments of research have been seriously advanced before these departments have had time to prove their rights to existence. It is not infrequently suggested, likewise, by otherwise irreproachable correspondents, that the experts of the laboratories and observatories of the institution be set at work under the direction of amateurs, or, in some cases, of those even who have not reached that earliest stage of capacity in science.

It goes without saying that all such untoward influences should have little effect on the rise and progress of a research establishment; but he would be an incompetent administrator who failed to recognize the existence and the dangers of these influences. Most men are still opportunists; many contemn principles and theories of procedure; while the characteristic defect of deliberative bodies, strikingly illustrated by legislative assemblies, is lack of deliberation. Moreover, what any organization, altruistic or otherwise, may accomplish at any epoch, or during any period, will depend very largely on the status of contemporary public opinion. No organization may be rationally expected to rise much above the level of the ideals of those who support and direct it. The law of averages and the "law of conservation of ignorance" apply in the business of research no less rigorously than in other affairs of human endeavor. The only difference is that in research, from the nature of the case, we are held to stricter accountability; it is incumbent on us to be alive to the ideals and the theories which lead to regress as well as alive to the ideals and the theories which lead to progress.

Although popular opinion continues to look upon the institution as an establishment of unlimited means, and hence of unlimited capacities, it is an easily ascertained fact that such advances as have been attained are due chiefly to concentration of effort in a few fields of investigation, the number of these being necessarily limited by the finiteness of income. Of the agencies which have contributed most to these advances the departments of research must be given first rank when quality and quantity of results accomplished are taken into account. These departments have supplied also a much needed verification of the axiom hitherto admitted in all domains of activity except those of research, namely, that if any good work is required the best way to get it done is to commit it to competent men not otherwise preoccupied. They have verified, likewise, the equally obvious truth that large and difficult undertakings demand foresight and oversight, prolonged effort, and a corresponding continuity of support. The idea that discoveries and advances are of meteoric origin and that they are due chiefly to abnormal minds has been rudely shattered by the remorseless experience of the institution.

Along with these considerations special mention should be made of another of vital importance to the departments of research. This is their complete autonomy within the limits of their annual appropriations. Allusion is made to this matter here partly for the purpose of correcting public misapprehension concerning the relations of these departments to the institution as a whole, and partly for the purpose of stating formally the theory of administration followed by the institution during the past twelve years. Such a degree of freedom accorded to the departments of research is

not only necessary by reason of the extent and the complexity of the affairs of the institution, but it should be regarded as a fundamental principle of sound administration. No one can follow the details of all these varied affairs. A division of labors is indispensable, and to the greatest extent practicable the director of a department of research should be encouraged to be the autocrat of his departmental destiny. But in so far as departments are granted liberty of action it is an equally fundamental principle of administration that they should assume corresponding responsibilities. Autonomous freedom and reciprocal accountability are then, in brief, the essentials of the theory under which the departments of research have evolved.

In consonance with the theory just indicated and in conformity with the precedent set a year ago, no attempt is made here to furnish abstracts of the current departmental reports. They give sufficiently condensed summaries of departmental activities and departmental progress. They are, as a rule, highly technical papers and difficult of adequate appreciation even by those somewhat familiar with the subjects considered. But this is not only just as it should be, but it is inevitable if the investigations under way are worth making. Our confidence in them must be founded in large degree on the general principles revealed in the advancement of science. Great and admirable achievements were attained by the ancients prior to the epoch of recorded history; still greater achievements were attained by the Greeks, the Arabs, and the moderns down to the epoch of Galileo and Newton; while competent judges have estimated that greater progress was secured in the nineteenth century than during all previous history. It is quite within conservative reason, therefore, to assume that if we continue to follow those principles, now grounded in more than twenty centuries of repeatedly verified experience, in the light of accumulated and recorded knowledge, we may confidently expect to achieve corresponding further advances.

The question is sometimes raised as to how the efficiencies of investigators and of departments of research are, or possibly may be, estimated. Occasionally, also, there seems to be entertained along with this question the hypothesis that research is a commodity and that money is the chief agent in promoting its effective increase. But the currently common meaning of efficiency implied in this question and in this hypothesis is too narrow for application here. It applies rather to machines and to aggregates of men working like machinery for predetermined economic ends. In a broader sense, however, the question of efficiency of men and of organizations is worthy of considerate attention. It is, indeed, in this inclusive sense, a question of the greatest importance, especially in all cooperative enterprises of communities and states. But without going into these larger aspects of the matter, it may be said that the efficiencies of the investigators and of the departments of research of the institution are determined in the same way that justification for the institution, as a whole, is determined, namely, by the consensus of competent opinion. In science, the work of an individual is measured on its merits and the work of an organization is weighed in the same manner. Adequate tests and standards for what is not fully known may not be wisely set up in acts of administration. Severer tests and higher standards are supplied automatically and relentlessly by contemporary criticism and by the verdicts of posterity. Hence, given a corps of trained investigators, or an organization of several such, the question of efficiency is happily one which is decided for us mainly

by those who are alone qualified to render adequate judgment.

Like all other branches of the institution, the division of research associates has undergone a distinct evolution. Originally a division which gave rise to excessive and often unrealizable expectations, it has gradually become shorn of its extrinsic appendages and divested of its inheritances from occultism. In spite of these omnipresent obstacles to progress and to efficiency, this division has been highly productive from the beginning and continues to be one of the most important agencies of the institution for the promotion of learning. The main reason for the noteworthy success of this agency is very simple. It was stated in a recommendation concerning research associateships, in the report of the president for the year 1906, in these words:

The limitation of eligibility for such positions to investigators of proved capacity for and of proved opportunity for research.

In the meantime, the number of those possessing such qualifications has increased much more rapidly than the resources of the institution (or than the resources of all research agencies combined) have increased to meet this and other growing financial needs. Not only has income failed to keep pace with worthy demands, but, as repeatedly pointed out hitherto, the purchasing capacity of income has steadily declined since the foundation of the institution. Thus it happens that now, just as the merits of the system of research associates have come to be generally recognized, it is essential to suspend extension of this system, and it may become essential to curtail to some extent the amounts of the grants hitherto made to those who have helped most to develop this remarkably effective division of the institution's activities.

It should be evident from the preceding paragraphs of this section of the report, as well as from numerous passages in previous reports, that the income of the institution is not only not equal to popular estimates, but that it is not equal even to the legitimate demands on it for research. This proposition is easily verified, although few people believe it and fewer still are willing to undertake the small arithmetical labor essential for its demonstration. On the other hand, it is admitted by everybody that the institution is not doing as much as it could, but the simple reasons for this obvious fact appear to be far from equally obvious. Whether it would be desirable, if practicable, to double, say, the endowment, and hence the income, of the institution is a question well worthy of consideration. But along with many reasons why it would be so desirable there might be adduced also many other reasons why it would not. This is, indeed, a fundamental question whose deliberate consideration should precede the next step. We possess as yet no well-defined and generally accepted theory of a research organization. The institution, plainly enough, stands somewhat in isolation. It would prosper better, probably, and be better understood, certainly, if it had more contemporaries with which to divide not only the vast fields of opportunity, but also the vast aggregate of fruitless labors imposed on those who should be preoccupied with the business of research. In the meantime, while no expansion is permissible under existing income, the current activities of the institution may continue without serious modification of plans or impairment of efficiency.

R. S. Woodward

SCIENTIFIC EVENTS

WIRELESS TELEGRAPH INSTALLATION AT THE UNIVERSITY OF CHICAGO

A notable addition to the equipment of the Ryerson Physical Laboratory at the Univer-

sity of Chicago has recently been made by the installation of wireless telegraph apparatus. The aerial will be stretched between the mast on Ryerson Laboratory and a similar one on Mitchell Tower, making available approximately a height of 140 feet and a length of 425 feet for the aerial conductor. This will consist of eight wires, each made of seven strands, which, including leads into the building, will require nearly six miles of phosphor bronze wire. The mounting and insulation will be most fully provided for in order to withstand a pull of three thousand pounds, which a heavy wind on ice-covered wires might produce; and also to make the electrical leakage negligibly small even when using the 20,000 volts which will be employed in transmission experiments.

The first transmitter will be of five kilowatts capacity, which will be sufficient for the present, though not suitable for transoceanic communication. The important parts of this apparatus are being made in the Ryerson Laboratory and already preliminary tests have shown that a high degree of efficiency will be attained.

All types of receiving instruments will be used and the excellent character of the aerial will make it possible to receive and experiment with the radiations from all the high-powered stations of the United States and with many of those of the European nations. Research work has already been started and arrangements made to carry on work in cooperation with another university as soon as the installation of the Ryerson apparatus is completed. Courses on the theory of wireless telegraphy and telephony coordinated with electrical measurements will be given during the coming summer quarter.

Associate Professor Carl Kinsley, of the department of physics at the University of Chicago, who prepared the substance of the foregoing statement, was for several years an electrical expert for the War Department and devised a wireless system, which was the first to be accepted by the United States government and is now in use by the San Francisco wireless station. Professor Kinsley has been connected with the University of Chicago for fifteen years.

THE LEASE OF THE TROPICAL BOTANICAL STATION AT CINCHONA

THE botanical station at Cinchona, in the Blue Mountains of Jamaica, formerly leased for ten years by the New York Botanical Garden, has now been leased by the Smithsonian Institution, on behalf of fourteen American botanists and botanical institutions that have contributed the rental. These botanists and institutions believe there is need in the American tropics of a counterpart of the famous Buitenzorg Garden in Java. They hope the opening of this laboratory at Cinchona may prove as stimulating to the development of botany in this country as the opportunities afforded at Buitenzorg have to the advance of this science in Europe.

The equipment available at the station consists of the residence, with its furnishings; of three laboratory buildings, two glass propagating houses and a garden of ten acres, containing scores of species of exotic shrubs and trees, besides many native plants from the highlands of Jamaica. The occupant of Cinchona is also free, within reasonable bounds, to study and collect plants over the many thousand acres of the whole Cinchona reservation, as well as in the neighboring valleys belonging to private owners. He will likewise be given every available facility for study at Hope Gardens, where he will find a herbarium, a library and an extensive collection of tropical plants. The same privilege will be his at Castleton Garden which contains a splendid collection of cycads, of palms, and of *Ficus* and other dicotyledonous trees.

The many different types of native vegetation accessible from Cinchona and from Hope, include a number of great ecological interest and numerous species of importance for the morphologist, cytologist and physiologist. The ecological types range from the tree ferns, epiphytes and water-soaked filmy ferns of the cool mountain forest to the hot, steaming woods of the lowlands of the north side at one extreme and to the dry savannahs and cactus deserts near Kingston at the other. Fuller

statements of the opportunities for research in various lines, written by men who have worked there, may be found in SCIENCE, Vol. 43, p. 917, 1916. (See also *Popular Science Monthly,* January, 1915.)

Any American investigator may be granted the use of the Cinchona Station by the Cinchona Committee, which consists of N. L. Britton, John M. Coulter and Duncan S. Johnson. Applications for this privilege and for information regarding the conditions under which it is granted should be sent to Duncan S. Johnson, Johns Hopkins University, Baltimore, Md.

THE COUNCIL OF NATIONAL DEFENSE

THE Council of National Defense and its advisory commission, composed of civilians, have decided to appoint seven committees to further develop the program for the mobilization of the resources of the country. They have issued the following statement:

The program of the council and commission has for its object the provision of an adequate military and naval defense based on an adequate industrial and commercial coordination and preparation. To attain this end, a definite, immediate and continuing program is being worked out.

The commission has divided into committees. A member of the commission is the chairman of each of the committees. Committees have been formed to take charge of the following subjects, and other committees will be formed as they may be needed.

A. Medicine, including general sanitation, Commissioner Franklin H. Martin, chairman.

B. Labor, including conservation of health and welfare of workers, Commissioner Samuel Gompers, chairman.

C. Transportation and communication, Commissioner Daniel Willard, chairman.

D. Science and research, including engineering and education, Commissioner Hollis Godfrey, chairman.

E. Raw materials, minerals and metals, Commissioner Bernard Baruch, chairman.

F. Munitions, manufacturing, including standardization and industrial relations, Commissioner Howard Coffin, chairman.

G. Supplies, including food, clothing, etc., Commissioner Julius Rosenwald, chairman.

The chairman of each committee will call a series of conferences with representatives of trades, businesses or professions. At such conferences the representatives shall be asked to organize so as to deal with the council through one man or through a committee of not more than three men, to whom the council shall submit problems which may affect the national defense and welfare.

One or more members of the council will meet the conferees and set forth the desires of the government and its needs. To quote the words of the enabling act, these needs are "the creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the nation."

The chairmen were authorized to select committeemen from either government or civil life.

THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE annual meeting of the National Academy of Sciences will be held at the Smithsonian Institution in Washington on April 16, 17 and 18, 1917.

By direction of the council and of the program committee, members are invited to present brief announcements, not exceeding ten minutes in length, of new discoveries and of the results of current research work, somewhat similar in scope and character to the announcements regularly made in the Proceedings. Titles, accompanied by an abstract of 100 or 200 words, should be sent to the chairman of the program committee, Professor B. B. Boltwood, Yale University, New Haven, Conn., not later than March 30, in order to be included in the program to be printed in SCIENCE. Titles which reach the chairman later than March 30 will be assigned a place by the program committee so far as time permits. About one third of the scientific program has been reserved for these announcements; the remainder will be arranged by the program committee. The sessions will be held as follows:

Monday, April 16

9.30 A.M. Business session, U. S. National Museum.

10.30 A.M. Scientific session (open to the public), U. S. National Museum.

2.30 P.M. Scientific session (open to the public), U. S. National Museum.

4.00 P.M. First William Ellery Hale Lecture,

by Edwin Grant Conklin, professor of zoology, Princeton University. Subject: "Methods and Causes of Organic Evolution" (open to the public), U. S. National Museum.

9.00 P.M. Reception, main hall, Smithsonian Institution.

Tuesday, April 17

9.30 P.M. Business session, U. S. National Museum.

10.30 A.M. Scientific session (open to the public), U. S. National Museum.

2.30 P.M. Scientific session (open to the public), U. S. National Museum.

8.00 P.M. Annual dinner, Raleigh Hotel. Presentation of medals.

Wednesday, April 18

9.30 A.M. Business session, U. S. National Museum. Election of officers and members.

1.30 P.M. Luncheon, Raleigh Hotel.

3.00 P.M. Scientific session (open to the public), U. S. National Museum.

4.00 P.M. Second William Ellery Hale Lecture, by Edwin Grant Conklin, professor of zoology, Princeton University. Subject: "Methods and Causes of Organic Evolution" (open to the public), U. S. National Museum.

SCIENTIFIC NOTES AND NEWS

THE portrait by Henry Ulke of Joseph Henry, first secretary of the Smithsonian Institution, has been transferred by a senate resolution, from the capitol to the Smithsonian Institution, where it has been hung in the National Gallery of Art, in the new building of the National Museum.

DR. WILLIAM H. WELCH was the guest of honor at the tenth annual banquet of the Æsculapian Club, Philadelphia, on February 6.

PROFESSOR AUSTIN F. HAWES, head of the forestry department of the University of Vermont and state forester, has resigned. Two positions were created lately in the United States Government's States Relations Service, foresters in charge of the Agricultural Extension work, one for the Cotton Belt States and one for the states of the north and west, the last of which Professor Hawes will fill.

DR. FABIAN FRANKLIN, associate editor of the New York *Evening Post* since October, 1909, has resigned. Dr. Franklin was professor of mathematics in the Johns Hopkins University from 1879 to 1895.

DR. MORTON G. LLOYD, formerly technical editor of *The Electrical Review* and *Western Electrician,* has accepted a temporary appointment as associate engineer in the Bureau of Standards, Washington, D. C.

K. F. KELLERMAN has been promoted from the position of assistant chief to that of associate chief of the Bureau of Plant Industry, U. S. Department of Agriculture.

DR. WATSON L. WASSON, professor of mental diseases in the college of medicine of the University of Vermont, has accepted the position of superintendent of the Vermont State Hospital for the Insane at Waterbury to succeed Dr. Don D. Grout, who has resigned. Dr. E. A. Stanley has been appointed to succeed Dr. Wasson at the University of Vermont. He has been a member of the hospital staff for some time.

AFTER seven months' absence in Japan, Korea, southern Manchuria and China, Assistant Professor Wellington Downing Jones, of the department of geography at the University of Chicago, has returned to the university for his regular work. The purpose of his trip to the Orient was to get a general view of the regions visited so as to be able to study intelligently what has been written about them, and also to plan effectively future detailed field investigations.

IT is stated in *Nature* that Captain Amundsen, the Norwegian explorer, who proposes to endeavor to reach the North Pole by aeroplane, is on his way to Norway from America to complete his plans. The ship in which he will make the first part of the journey is to be launched at Christiania next March, and Captain Amundsen expects to start his scientific expedition about the summer of next year. He hopes eventually to come in touch with Robert A. Bartlett, another explorer, who is going via Bering Strait.

AT the annual meeting of the Royal Microscopical Society, held on January 17, the following officers were elected for the year 1917: *President,* E. Heron-Allen; *Vice-presidents,* J.

E. Barnard, A. Earland, R. G. Hebb, F. Shillington Scales; *Treasurer,* C. F. Hill; *Secretaries,* J. W. H. Eyre, D. J. Scourfield; *Librarian,* P. E. Radley; *Curator of Instruments,* C. Singer; *Curator of Slides,* E. J. Sheppard; *Editor of Journal,* R. G. Hebb.

PROFESSOR FREDERIC S. LEE, of Columbia University, lectured before the Science Club of the University of Wisconsin on February 12, on "Air and Efficiency."

ON February 8 Professor Murlin, of Cornell University, addressed a meeting of the Biological Society of the College of the City of New York on "The Relation of Acidosis to Carbohydrate Metabolism." Professor Abraham J. Goldfarb and Dr. Dayton J. Edwards participated in the discussion following the lecture.

PROFESSOR WILLIAM K. GREGORY, of Columbia University and the American Museum of Natural History, delivered an illustrated lecture before the Biological Society of the College of the City of New York on "The Evolution of the Human Race," on March 1.

NEARLY $400,000 was bequeathed in 1910 to the city of Munich by Dr. G. Krauss to found, as a memorial to his father, an institution for mechanical and other forms of orthopedics, especially those practised by the elder Krauss. The building is now completed. It stands on the grounds of the university orthopedic clinic with which it is closely affiliated, Professor F. Lange being in charge.

EDWARD DYER PETERS, Gordon McKay professor of metallurgy, Harvard University, died on February 17, in the sixty-eighth year of his age.

C. OWEN WATERHOUSE, formerly assistant keeper of the British Museum of Natural History, died on February 4, at the age of seventy-three years.

THE death is announced of J. M. Alvarez, professor of hygiene at the University of Cordoba, Argentina, senator of the realm and governor of the Province of Cordoba, aged fifty-seven years.

THE death at the age of fifty-four years is announced of Dr. H. Schulthess, of Zurich, known for his work on heart diseases, the sphygmometer and photography of the pulse.

M. HONNORAT, deputy of the department of the Lower Alps, is said by the *Journal of the American Medical Association* to have ready for publication the demographic statistics of France for 1915. The data at hand are as follows:

Years	Births	Deaths
1913 (77 departments)	604,454	588,809
1914 (77 departments)	594,222	647,549
1915 (76 departments)	382,466	644,301

Therefore, in the departments which can be accounted for, registry shows: in 1913, an excess of 15,645 births; in 1914, an excess of 53,327 deaths, and in 1915, an excess of 261,835 deaths. The figures do not represent correctly the births and deaths in the invaded departments in the war zone, where almost all the deaths of combatants are registered.

THE Imperial Russian Society of Mineralogy celebrated its centenary in January. Owing to existing circumstances, a special session was not held, but there was a general meeting and an exhibit showing the history of the society.

AT the two hundred and twenty-eighth meeting of the Elisha Mitchell Scientific Society at the University of North Carolina on February 20, Mr. Collier Cobb spoke on "Recent Changes in Currituck Sound," and Mr. Horace Williams on "The Philosophy of Science."

THE second annual Drainage Conference of the University of Illinois is to be held March 13–15, 1917. Engineers, drainage officials, contractors, public officials, land-owners and business men from all parts of the state will be in attendance to consider such subjects as the reclamation of swamp and overflowed lands, flood control and the conservation of the soil. The subject of land reclamation in Illinois is one of greater importance than is generally supposed. Although some three million acres of uplands have been drained, there remain great overflow areas of rich lowlands along the rivers, the aggregate extent of which is greater than that of Holland and the reclamation of which would add $150,000,000 to the land values of the state. The conference to be held at Urbana will have for its purpose the

stimulation of greater interest in this problem. The speakers will be engineers and public officials of prominence and information regarding the practical phases of drainage will be made available to those in attendance. The organization and financing of drainage districts, the surveying of drainage areas, the design of systems and improved methods of construction are among the subjects to be considered. The meeting will be in charge of the department of civil engineering, college of engineering, Urbana, Illinois.

"ASPECTS of Modern Science" is the general subject of a series of lectures being given by members of the faculties of the University of Chicago, at the North Side Center of the University Lecture Association of Chicago. The series was opened on February 19 by Professor Robert A. Millikan, of the department of physics, who spoke on "Modern Views of Electricity." On the evening of February 26, Associate Professor William Draper Harkins, of the department of chemistry, discussed the subject of "Radium, the Breaking Up of Atoms, and the Evolution of the Elements." On March 5, Professor John Merle Coulter, head of the department of botany, will lecture on "The Revolution in Agriculture," showing how the investigations of heredity and of the soil have revolutionized agricultural practise and bid fair to solve the pressing problem of food production. On March 12, Associate Professor Walter Sheldon Tower, of the department of geography, will discuss "The Meaning of Modern Geography," and, on March 19, Director Edwin Brant Frost, of the Yerkes Observatory, will present some of the "Revelations of the Spectroscope." The closing lecture, "The New Geology," on March 26, will be given by Dean Rollin D. Salisbury, of the Ogden Graduate School of Science, who will present some of the newer theories concerning the earth's history, especially its origin and its age.

UNIVERSITY AND EDUCATIONAL NEWS

PRESIDENT WILSON signed, on February 23, the Smith-Hughes Vocational Education Bill, which provides large funds for federal aid to the states for the teaching of agriculture, trade, industries and home economics.

MR. AND MRS. MAX EPSTEIN, of Chicago, have contributed to the medical school enterprise of the University of Chicago $100,000 to erect and furnish the equipment for a university dispensary. This will provide a structure in which will be reception rooms, rooms for diagnosis and treatment, rooms for hospital and dispensary social service work and workers both professional and volunteer.

MR. FRANK G. LOGAN, of Chicago, has given to the University of Chicago a fund providing an income of $3,000 a year for three research fellowships, one in pathology and bacteriology, one in medicine and one in surgery.

AT a recent meeting of the faculty of the Long Island College Hospital it was voted to admit women students on the same terms as men.

IT is stated in *Nature* that Mr. E. J. C. Rennie, son of Professor Rennie, of the University of Adelaide, has been appointed acting lecturer in electrical engineering in the University of Melbourne. He will take the place of Mr. E. B. Brown, who is about to engage in munition work in England.

DR. C. E. MOSS, of the University of Cambridge, has been appointed professor of botany in the South African School of Mines and Technology, Johannesburg.

DISCUSSION AND CORRESPONDENCE

PHOSPHATE EXPERIMENTS

IN SCIENCE, January 5, 1917, pages 18 and 19, Professor C. A. Mooers writes as follows concerning the results of Tennessee experiments with different phosphates:

> Neither now nor in the past have these results allowed us to advocate, as intimated by Dr. Hopkins, the use of unacidulated bone meal. From the standpoint of economy, the data obtained here have been decidedly in favor of acid phosphate. In Dr. Hopkins's article omission was made of the fact that in the table referred to—Bulletin 90, p. 89, Tennessee Agricultural Experiment Station—every $1.00 invested in acid phosphate gave on the average a calculated profit of $4.28 where the

cowpea crops were turned under, and of $5.42 where they were removed for hay. Phosphate rock, on the other hand, gave by a similar calculation a profit of only $2.58 where the cowpea crops were turned under and the same amount where they were removed for hay.

On pages 87 and 88 of the Tennessee bulletin, No. 90, Professor Mooers makes the following statements:

The steamed bone meal, although included among the relatively insoluble phosphates, appears in these experiments to occupy an intermediate place, with returns little inferior to those from acid phosphate. As compared with phosphate rock the mechanical condition of the meal is in its favor; also its content of organic matter is supposed to assist in its decomposition. But in these experiments the influence of the nitrogen contained in the meal must not be overlooked and probably gives it a higher standing than can be attributed to the phosphoric acid alone. Evidently it is a valuable fertilizer for soils like these, and the confidence placed in it by many farmers of the Highland Rim and other parts of the state seems not to have been misplaced.

The calculated profits mentioned in Professor Mooers's SCIENCE article are evidently based upon different valuations than those reported in the bulletin, as may be seen from the following table taken from page 89 of the bulletin:

RESULTS OF TENNESSEE EXPERIMENTS

Cowpea Crops Turned Under

Phosphates Used			Calculated Profit	
Kind	Amount	Cost	Unlimed	Limed
Acid phosphate	229 lb.	$1.83	$3.37	$4.47
Bone meal	218 "	3.27	3.13	2.73
Phosphate rock	383 "	1.53	2.57	1.37

Cowpea Crops Removed

Acid phosphate	261 lb.	$2.09	$5.34	$5.98
Phosphate rock	385 "	1.54	4.73	−0.77

Easy computations show profits per $1.00 invested of $0.90 from bone meal and $1.29 from phosphate rock, as an average of the comparable figures.

On page 90 of the Tennessee bulletin Professor Mooers makes the following statement:

There seems, therefore, to be little promise in phosphate rock on soils like those under consideration, unless liming be omitted, and even then the results of Series III. and IV. show that acid phosphate may be much more profitable than the untreated rock.

Computation from the figures in the accompanying table show average profits from the unlimed land of $2.20 from acid phosphate and $2.38 from raw rock phosphate, for every $1.00 invested.

When we consider (1) that wheat was grown every year upon the same land in these Tennessee experiments; (2) that 70 per cent. of the phosphorus in the raw phosphate applied will remain in the soil for the benefit of future crops after the acid phosphate is exhausted; (3) that raw rock phosphate is now procurable in very much better mechanical condition than when these experiments were conducted; (4) that, as an average of sixteen years at Wooster and nineteen years at Strongsville, Ohio,[1] the increase in crop values were $4.01 from non-acidulated bone meal and $3.78 from acidulated bone black, on adjoining plots in a five-crop rotation system, providing for every crop every year; and (5) that, as an average of results from twenty years of investigation by the Rhode Island Experiment Station,[2] better returns per $1.00 invested were secured on both limed and unlimed land from both raw rock phosphate and ground bone than from any one of four different acidulated phosphates; then we find still more difficulty in harmonizing all expressed opinions with the established facts. CYRIL G. HOPKINS

UNIVERSITY OF ILLINOIS

THE ORGANIZATION MANIA

TO THE EDITOR OF SCIENCE: It is to be hoped that the Report of the Subcommittee on Research in Industrial Laboratories, published in SCIENCE for January 12, marks the high water mark of the organization mania now sweeping the country. The research worker must have an assortment of extraordinary qualifications.

[1] Ohio Experiment Station Circulars 104 (p. 11) and 144 (p. 97).

[2] Rhode Island Experiment Station Bulletin 163, p. 547.

Nothing is said, however, of what rewards, either financial or social, are for him. Apparently he should be willing to be a cog in a machine in an institution. It is difficult, says the Report, to locate "a skilled private assistant—one who possesses not only originality, but also sound judgment and intellectual honesty." If you add to these qualifications a handsome appearance, you will have nearly the perfect man—and then you offer him the glorious position of private assistant. Happily, however, he will not be foolish enough to take it. He will make more money, have more independence, and win more social esteem if he devotes his originality to writing "compelling" soap advertisements. He will also have an infinitely easier life.

The amazing statement is made that "the individual can exert only a very small influence except as a member of an organization." One wonders what institution or organization Newton or Darwin belonged to, without which "they would have exerted only a very small influence." Coming nearer home, to what institution does Mr. Baekeland or Mr. Elihu Thomson belong?

The best possible thing that executives can do for science is to efface themselves as much as possible. Thank heaven, the "centralizers and coordinators" (as Sir Ronald Ross calls them) did not get hold of Dalton or Faraday or even Shakespeare, for creative originality is the same, substantially, to whatever it may be applied. Not only do executives often absorb salaries that ought to be paid to research workers, but they create a public impression that the workers are their subordinates, as if a scientific worker were an inferior sort of animal who needed some one to coordinate his activities.

Executives also absorb some of the most stimulating parts of the work—the planning and prominent public expression. Worst of all, they operate to deprive a scientific worker of that independent position which is the life blood of a man of original and vigorous habit of mind. The proper model of the scientist is the judge. The lack of independent position surely drives many away from fruitful work. The writer knows two men of scientific training and of vigorous and original minds who went into the advertising business. Needless to say, they are earning vastly more, and are enjoying a far more independent position, than the majority of scientific workers. No executive tells them to "cooperate." They cooperate or not, just as they see fit.

Of course cooperation comes in strong in the report, even if it works to deprive talent of its just rewards. Originality is not joint but personal. An army wins a battle, but the creative thinking is commonly done by some one Napoleon. The writer knows of a case recently where an organization worked on a problem for many months without achieving anything except more or less useful (mostly trivial) data. But one day a member not working on that problem, devoted some high tension thinking to the subject, aided by a happy combination of other knowledge, and was able to see the solution of the whole question on radically different lines. If he had turned in his contribution, he would have received only minor recognition, as he had spent only a short time on it. As it was, he kept it to himself and is now reaping a legitimate reward. How could his inventive originality be asked to divide the credit and rewards with mere data collecting—for the two things are not commensurate? To use a current expression, they are "not in the same class." And yet he should not be secretive, *i. e.,* talent should give its ideas to mediocrity. There are kinds of cooperation where one eats the dinner, and the other pays the check and tips the waiter and cloak room girl besides.

Other scientists would do well to take a leaf from the surgeon's book. Certainly in part, the high position of American surgery is owing to the fact that the surgeon's work is his own. I presume that the Mayo brothers have an "executive," precisely as any hospital has a manager, who attends to the buying of supplies, etc., but nobody ever heard of him. It is curious how American surgeons have been able to do such good work with no "executive surgeons" to occupy the center of the stage, and make them cooperate. Incredible as it may

seem, in this field the mahogany roll-top desk is not the greatest thing in the world.

Says Professor Fite in the *Nation:*

> Wherever two or three are gathered together, and even where they are not gathered together, some one is on his way to organize them. In the madness for organization we have long since lost sight of the end in the means; we have forgotten that neither the fruition nor the advancement of human life can take place in the absence of individual freedom and creativeness, and we have come to believe that the sole meaning of life and of culture is—to be organized.

INDIVIDUAL

SCIENCE AS CONTRABAND

To the Editor of Science: Through the kind offices of Professor James Ward the British authorities have consented to release the books sent from Germany to the *Psychological Review.* The Psychological Review Company desires to express its thanks to Professor Ward.

For the benefit of other scientists who may be similarly involved it should be stated that the action taken was a pure act of courtesy to Professor Ward. The taint of contraband still infects scientific literature in the opinion of the procurator general; but he is willing to defer to expert judgment.

Howard C. Warren

Psychological Review Co.,
Princeton, N. J.,
February 20, 1917

TRIMMED MAGAZINES AND EFFICIENCY EXPERTS

To the Editor of Science: Your correspondent "H. P." waxes somewhat warm in your issue of January 12 on the above subject and evidently prefers his untrimmed. To me it seems "all nonsense" to say that "I have always found that I got more out of an unopened magazine than an opened one." The contents are of course the same in either case, the difference is in one's mental attitude. I find my weekly copy of Science so interesting that I almost invariably read it clear through, and I do not want to be delayed in getting at its contents by having to cut its pages. I find it very irritating to have to cut the pages of an interesting book when I had much rather be reading it. Such work is to me a waste of time and energy. Science is read weekly by some 12,000 to 15,000 busy men and women whose time is valuable in the literal as well as in the figurative sense, hence the "general opinion that the copies should be trimmed." This suits the present writer, but it is to be regretted that "H. P." can no longer get his untrimmed.

E. W. Gudger

State Normal College,
Greensboro, N. C.,
February 1, 1917

QUOTATIONS

INTELLECT AND THE WAR

Had not experience amply shown that no subject is so remote as to make it exempt from contact with the workings of the great war, one might expect such immunity in the case of a paper on "The Relations of Mathematics to the Natural Sciences." As it is, one is not in the least surprised to find that the bearing of the present state of the world on the future of mathematical research is the theme of the closing remarks in the presidential address with that title delivered at the recent meeting of the American Mathematical Society by Professor E. W. Brown, the distinguished mathematical astronomer of Yale. While the stupendous events of the past two years have caused the need for scientific research to be emphasized more strongly than ever before, he says, yet it is to be remembered that in this the practical end alone is contemplated, and the purely intellectual side is little regarded. "The future of research in pure science is in danger as never before," he warns.

For this fear there is only too much ground, though in our judgment it would be a deplorable error to accept as inevitable that which is only threatened. No man can say what reaction there may be after the war from that state of mind which the appalling demands of such a conflict as is now convulsing the world inevitably produce. Everything depends on the nature of the peace which is to follow. If it is to be such as will compel a

state of gigantic preparedness for a renewal of the stupendous struggle, the constant expenditure and strain directly involved will be no more certain than such consequences in the domain of the intellect as Professor Brown foreshadows, and as other men concerned for the future of intellectual aspiration have undoubtedly been apprehending. If, on the other hand, the world shall be blest with such an outlook at the close of the war as will make the recurrence of such a calamity seem practically out of the question, it is by no means impossible that release from the fearful strain of the war will carry with it a spontaneous rush of lofty minds into regions as remote as possible from that into which the life of man had been so inexorably forced during the years of terror. To trust to any analogy of the past, when the present is in some vital respects so utterly without precedent, would be most unsafe; yet it is not without significance that in this very domain of pure mathematics two periods of the highest fecundity have occurred precisely when it might have been supposed that the minds of men were completely absorbed in the tremendous actualities of war. During and for some years after the wars of the First Republic and of Napoleon, there was in France such a flowering of mathematical genius and such splendor of mathematical achievement as have hardly been matched in the history of the world; and it was immediately after the war of 1870 that, after a long period of comparative quiescence, that same spirit flashed out in the brilliant group of mathematicians of whom Henri Poincaré was but one, though the most illustrious, exemplar.

However this may be, there can be no doubt that the gospel of relentless "efficiency" to which the war has given so great an impetus carries, deeply embedded in it, the seeds of hostility to all activities and interests which find their spring in intellectual aspiration or enthusiasm. At best, from the standpoint of the efficiency cult, such endeavors have to be justified by the plea that, divorced as they may seem to be from practical objects, they do conduce to the advancement of the common ends of the nation or of mankind, though the connection may be remote or subtle. The plea can be made good over a very broad area, and in the case of mathematics the constant interplay between the advancement of pure theory and the pursuit of its physical applications makes the task easier than in many other cases. But the argument is a thorny one; and that is not the worst of it. The mere necessity of resorting to such a defensive plea, the mere surrender of the proud conviction that the pursuit of truth is in itself a noble end which requires no secondary justification, must immeasurably depress the tone of scientific enthusiasm and impair the energy with which its objects are pursued.

And it has to be confessed that, long before the war began, long before any shadow of its approach had been cast upon the world, another factor was working powerfully toward the production of the same effect. For years, and most of all in this country, the idea that "service" is the only justifiable motive of intellectual endeavor had been steadily gaining ground. It is true that occasion has shown, again and again, that the intellectual world had not been swept from its moorings; that, as usual, the latest mode had been taken up by persons whose vocal facility produced a false impression both of their numbers and their weight. Nevertheless, the trend was marked enough to be important; and, unless checked by staunch self-assertion on the part of those whose convictions were deeper, as well as more informed, it threatened grave injury to one of the highest interests of civilized mankind. With the reinforcement which the developments of the war have from so different a quarter brought to this tendency, it is more than ever necessary for those to assert themselves who know how precious to the life of us all is that element which is supplied by the devotion of the lives of some to the pursuit of truth for its own sake, or even for the sake of the fame which is the natural reward of signal success. John Milton had perhaps as high an ideal of service as the youngest of our present-day reformers; yet it was not with contempt that he spoke of those who "scorn delights and live laborious days" in the pur-

suit of intellectual fame; nor did Newton do less for the greatness of his country, from whatever standpoint you choose to view it, by uncovering the secret of the universe than he would have done by sticking closer to earth in the strivings of his unrivalled intellect.—New York *Evening Post*.

SCIENTIFIC BOOKS

An Introduction to Historical Geology with Special Reference to North America. By WILLIAM J. MILLER. New York: D. Van Nostrand Company. With 238 illustrations. Pp. xvi + 399. $2.00 net.

The meaning of the word geology was greatly modified and vastly expanded in the early part of last century through the works of Wm. Smith, Cuvier, Brongniart and their followers. In the place of philosophical mineralogy the meat and marrow of the subject became earth history. To this phase of the subject Conybeare and Phillips devoted the greater portion of space in their well-known treatise of 1822. Lyell's tastes being largely along the line of the modern physical geographers, judiciously termed his great work not Geology, but the "Principles of Geology, or the modern Changes of the Earth and Its Inhabitants Considered as Illustrative of Geology." Yet he included in the earlier five editions of this work a large amount of stratigraphical matter gleaned during his various trips into the Tertiary fields of south Europe. In 1838, however, he excerpted the stratigraphical or historical matter from his "Principles," recast and enlarged upon the same and brought out a separate volume called "Elements of Geology." This ran through some half-dozen editions down into the "seventies" and was referred to by him as Elements of Geology, Students' Elements of Geology, Geology Proper or simply Geology. Some time before, however, De la Beche had foreseen the divisibility of the subject along similar lines, for he remarks in the preface to his treatise of 1833:

> It is not difficult to foresee that this science, essentially one of observation, instead of being, as formerly, loaded with ingenious speculations, will be divided into different branches each investigated by those whose particular acquirements may render them most competent to do so; the various combinations of inorganic matter being examined by the Natural Philosopher, while the Natural Historian will find ample occupation in the remains of the various animals and vegetables which have lived at the different periods on the surface of the earth.

A recent text-book of geology, by Pirsson and Schuchert follows practically the lines of subdivision suggested by De la Beche: Part I. is designated Physical Geology; Part II., Historical Geology. These parts may be purchased in separate binding. Another recent text-book by Cleland, is styled "Geology, Physical and Historical."

In Miller's work before us we have an independent volume styled "An Introduction to Historical Geology." This the author hopes "may find a place as a class-book dealing with the historical portion of a one-year course in general geology," adding, however, "An elementary knowledge of what is generally comprised under dynamical and structural geology is presupposed."

Except in this independent character of the work, Professor Miller's production does not differ radically from what has usually been found in the historical portion of the better text-books on geology. That is, the various periods are taken up in chronologic order. The origin of the name of the period, its subdivisions, distribution of rocks, physical history, foreign equivalents, climate, economic products, and life are the usual subdivisional topics. Under life, Plants, Protozoa, Porifera, Cœlenterata, Echinoderms, Molluscoids, Mollusca, Arthropods and Vertebrates, with subdivisions are systematically discussed. The author quotes freely from modern text-books, manuals and general geological literature, seemingly content to let well-enough alone. Likewise "appropriate illustrations more or less familiar because of their appearance in other text-books or manuals of geology, have not been abandoned merely for the sake of something new or different."

As regards the matter of allotment of space and attention to the several eras, we believe good judgment has been shown. 145 pages are

devoted to the Paleozoic; 80 to the Mesozoic; 100 to the Cenozoic. This is in pleasing contrast to what is seen in several recent works where an overweening preponderance is given to the Paleozoic, apparently because it was long! or, because the author's interests were largely in that era. To be sure some phases of the Mesozoic are ill represented in this country, and, in preparing a work for American students a less complete account of this era is permissible; but not so with the Cenozoic so grandly recorded throughout the length and breadth of this land. And again, in this era were evolved the teeming hordes of modern life on land, in sea and air, life of most fundamental interest to man, and man himself. Imagine a work on general history descanting on ancient civilizations, because they extended through vast periods of time! commenting more briefly on medieval epochs, and brushing aside with a few paragraphs the fundamentally important, profoundly intricate and comparatively accessible developments of modern history. The writer on historic geology has, however, greater difficulties before him than the assignment of space to eras. Above all comes the Herculean task of vividly portraying to the beginner the events of earth history by means of legitimate deductions drawn from fossil forms, all of which are unknown to the student. Whoever has listened to a lecture on a new subject in a strange tongue will appreciate the difficulty here referred to. The average American youth may listen profitably to a discourse on mountains, rivers, oceans, even perhaps on volcanoes and earthquakes. With animal and plant life in the form of horses, cattle, trees and grasses he is more or less familiar; but, in definite knowledge regarding the life of the sea—the very type the teacher wants to deal with most frequently—he is found wanting. We recall the startled look when he hears the common word Brachiopoda for the first time; we still respect the brilliancy of the student who mnemonically cinched *Tropidoleptus carinatus* not by its biological affinities but by the similarity of its specific name to "Carrie Nation." Professor Miller, like Dana and others, has recognized this general lack of biological preparation on the part of his readers and has devoted an introductory chapter to an outline classification of the animal and plant kingdoms. Thereafter, in orderly review, he gives under each period what is happening among the Echinoderms, Worms, Molluscoids, Molluscs, etc., etc. Now this orderly, card-index style of arrangement of facts is excellent in a book for reference only; but, the bringing up of each little branch of life again and again when not characteristically developed leads necessarily to the introduction of considerable unimportant matter; for example: "The Pelecypods and Gasteropods were still common, but they were in no important way different from those of the preceding period." Or: "Sponges were common but they require no special description."

It seems to the reviewer that such data might be confined to the excellent "Tabular Summary" at the close of each era. The question arises here, as in reference to the majority of texts on historic geology, would it not be better for the student's mental digestion, so to speak, if in place of this menu of a vast number of short-order courses a few well-balanced rations of carefully selected matter were served. Schuchert in the textbook already referred to has apparently acted upon this principle, interlarding his chapters on physical history of the periods with substantial essays on a few dominant types of life characteristic of each great geological period. Time will determine whether the student profits more by being continually reminded of the progress of the various minor subdivisions of life, or, by receiving once and for all a thoroughgoing discussion of a few great, dominant life-forms.

Professor Miller's book seems remarkably free from the small, yet sometimes ludicrous, mistakes that often appear in first editions. Quite probably, however, he will change the wording in the following sentences somewhat in the next edition of the work: (Page 106) "Conformably above the Clinton beds lies the Niagara limestone, which has a still wider distribution than the Clinton."

(Page 136) "All known Devonian vertebrates were aquatic."

(Page 321) "During the Pliocene and Quaternary, *Equus*, or the modern Horse, has one toe only on front and hind feet with the two side toes of *Protohippus* reduced to splints (the fetlock of the present day Horse)."

(Page 305) "In this vastly expanded interior sea true marine deposition took place, the most characteristic formation being a Nummulitic limestone, so called because it is chiefly made up of shells of a certain species (*Nummulites*) of unusually large Foraminifers. Perhaps no other single formation in the crust of the earth built up essentially of the remains of but one species of organism is so widespread and thick, its thickness at times reaching several thousand feet."

(Page 334) "At no time did the Labradorian ice sheet spread enough eastward or the Kewatin sheet far enough westward, to cover this driftless area."

Typographical errors in this book are rare. We now recall having noted but two, one in the caption of page 193, the other in the spelling of the specific name *choctavensis*, page 315.

The illustrations upon the whole are good. The printing of whole-page half-tone engravings on the class of paper used in the text (though very good) is scarcely to be recommended, as the plate on 129 clearly shows. The routing on the line engraving, Fig. 69, page 126, was carelessly done. Slight stains, perhaps from the paste used in securing the illustrations appear about their borders, in Fig. 52, page 95.

The printing is of uniformly good grade, the body type approaching very closely the 10-point modern Lining Roman No. 510 opened up by two point leading, giving always a clear, pleasing appearance. The paper, very slightly reddish tinted, is about 70 lb. book, scarcely shiny, but sufficiently calendered to take small half-tone engravings to advantage.

To sum up: Professor Miller has carefully compiled from recognized authorities facts and figures illustrative of historical geology as now generally understood. He is no iconoclast. He has apparently felt the need of a systematic tabulation of topics, serving as a ground-work for a series of lectures in historic geology. This with minor expansions and articulations forms the text-book before us. What were his needs are likewise the needs of other teachers of the same subject; and, since he has done his work well and his publishers have cooperated with good judgment and artistic ability, there would seem to be no reason why the book should not meet with deserved success.

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SPECIAL ARTICLES

BOILING BUFFALO CLOVER SEED

The discovery that the process of boiling the seed of spotted bur clover (*Medicago arabica*) one minute insures good germination has resulted in the adoption of the practise by the farmers of the south. The kindred discovery recently made by the writer that the seed of buffalo clover (*Trifolium reflexum*) can be readily germinated in the same manner, opens the way for experiment station men to investigate the economic merits of this little-known clover. Experiments heretofore attempted have been nipped in the bud, as far as is known, by failure to obtain a stand. With the practise of soaking and boiling, however, stands can be obtained and the merits and demerits of this legume can be found out.

In 1914, after successfully germinating spotted bur clover seed by the boiling process, the same method was tried by the writer on red clover, white clover, sweet clover and alfalfa, but with negative results. A single experiment with buffalo clover at that time increased the germination from four to thirty per cent. by boiling one minute, but this was considered too small a per cent. and the matter was dropped. Recently, however, the experiment was tried again in a slightly modified form and with excellent results.

The details of the experiment were as follows:

Treatment	Per Cent. Germination
None	0
Boiled 5 seconds	53
Boiled 30 seconds	60
Boiled 60 seconds	60
Soaked in cold water 12 hours	0
Soaked in cold water 12 hours and boiled 5 seconds	47
Soaked in cold water 12 hours and boiled 30 seconds	87
Soaked in cold water 12 hours and boiled 60 seconds	93

Buffalo clover is scattered over many states as a wild plant, but is cultivated nowhere. It somewhat resembles red clover in general appearance and habit of growth, but is smaller. Its leaves are narrower and more sharply pointed and its head, when dead ripe, turns over and hangs down like the heads of white clover. It is large enough to have value if it has other desirable qualities.

The writer obtained the idea of soaking the seed before boiling from similar experiments with bur clover by the Alabama Experiment Station. The fundamental experiment of boiling the seed of both species was original, however, with the writer. A. D. McNAIR

GOLDFISH AS EMBRYOLOGICAL MATERIAL

FEW laboratories have at their disposal a constant supply of material for the study of living embryology. Frog and snail eggs are used occasionally, but the supply is uncertain and sometimes difficult to obtain in the right stages, and furthermore, these ova are not particularly favorable for study. While engaged in an investigation on the genetics of goldfish the availability of the eggs of this animal for studies on the living embryo became evident and led to this note.

Goldfish are readily obtained in almost every locality and are thoroughly normal in environments in which few wild fish could exist. They breed in tanks containing not more than fifteen or twenty gallons of water and consequently require no elaborate or extensive equipment. Cypress boxes a foot or more square and three feet long make excellent breeding tanks.

A half dozen pairs or less will supply ample material for class use. It is not necessary to have as many males as females. It is well to obtain fish at least four or more inches long, as the larger fish are more certain to mate and are much more prolific. It is impossible to distinguish the sexes except as the breeding season approaches, when the sides of the female become distended through the growth of the ovaries and small spiny projections appear on the operculum and the anterior edge of the pectoral fins of the male.

One or two months before the breeding season begins it is advisable to feed the adults small quantities of beef, liver, mosquito larvæ or worms several times a week, which strengthens the fish and often advances the mating season. If the fish have been properly fed in the fall, spawning may begin as early as January or February if the aquarium is in a fairly warm place, although I have seldom obtained eggs before March or April.

During the season goldfish spawn at intervals of two weeks or longer and experienced breeders say that large vigorous females may breed as frequently as eight times during the spring, though in my work four or five matings have been more usual. The number of eggs spawned ranges from a few hundred to several thousand at a period, depending on the size of the female, and consequently the season's production, even allowing for unfertilized ova, is very great.

Goldfish spawn in the morning for periods varying from two to eight hours. The female discharges a small quantity of eggs against some water plant and the male, who is at her side at the time, fertilizes the eggs in the water. The feathery roots of the water hyacinth seem to be preferred, although the water plants, myriophyllum and cobomba are very satisfactory. The eggs adhere to the plants and may be removed on them. When it is desirable to time the fertilization accurately the plants may be removed as fast as the ova are discharged against them and others substituted. Though the eggs may be removed from the thread-like leaves or roots of the water plants generally these threads do not interfere and make a convenient handle for moving and

orienting. The unfertilized ova become milky and opaque within twenty-four hours.

Stripping these fish is not entirely successful, as the eggs are so sticky that they clump together and adhere to the fingers of the operator or to anything else they may touch. Moreover, it is difficult to obtain sufficient sperm for a large number of eggs by stripping the male. It is perfectly possible, however, to obtain a few eggs from the female in this way and enough sperm to enable the process of fertilization to be studied under the microscope. Attempts to strip should only be made on those fish which are actually beginning to spawn, when the eggs will flow freely. At this time there is little danger of injuring the female. It is usually possible to determine at least twenty-four hours before the act begins which female is ready to spawn, as the males will follow or chase her about the tank.

The eggs take from two days to a week or more to hatch, depending on the temperature. The ova are perfectly transparent and the developing embryo is easily visible under the binocular.

Further directions for breeding that may be desired can be found in the books of Smith[1] and Wolf.[2]

ROBERT T. HANCE

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[1] Smith, Hugh M., 1909, "Japanese Goldfish," W. F. Roberts Company, Washington.

[2] Wolf, Herman T., 1908, "Goldfish Breeds and Other Aquarium Fish," Innes and Sons, Philadelphia.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION M—AGRICULTURE

ON account of the unusual number of bodies meeting at New York during convocation week whose field borders on agriculture, the Section of Agriculture held only a single session. This occurred Wednesday afternoon, December 27, 1916, in Brinckerhoff Theater, Barnard College, Columbia University, and was presided over by Dr. W. H. Jordan, of the New York Experiment Station. In the absence of the retiring vice-president, Dean E. Davenport, of Illinois, who was unable to reach the meeting on account of delayed train service, it was necessary to dispense with the vice-presidential address. This address was entitled "The Outlook for Agricultural Science" and has been published in this journal.[1]

The feature of the session was a symposium on "The Adjustment of Science to Practise in Agriculture," participated in by Dr. H. J. Wheeler, of Boston, Dr. J. G. Lipman, director of the New Jersey Experiment Stations, Dr. G. F. Warren, of the College of Agriculture at Cornell University, and Director B. Youngblood, of the Texas Experiment Station. Approaching the subject from different angles, the speakers brought out the many important considerations which affect the adjustment and determine the extent of the application of the teachings of science in agricultural practise.

Discussing "Some Factors lying between Scientific Results and the Farm," Dr. Wheeler laid down the proposition that true science is always in accord with the best practise; there is no antagonism between science and good practise, although political, economic and other factors may intervene to modify the extent to which the findings of science are profitable or directly applicable. The prosperity of the farmer is a prime requisite to the application of science in his business. The element of risk is unusually large in farming, and uncertainty as to the character of the season and the price of his products often makes the farmer of limited means hesitate to introduce changes suggested by science. A favorable tariff has in some countries been a large factor in creating conditions under which science can be profitably applied, together with a larger element of stability of the industry.

It was held that agriculture must be stimulated by political action; if the industry is depressed so that the farmers are not making money, science can not lend an effective helping hand to the art. The encouragement of private ownership of land, the adjustment of the farm to the farmer's capacity, and adjustment of the farming system so as to distribute and give employment to the labor throughout the year, are all important as determining factors lying between knowledge and its utilization on the farm. The condition of the land as, for example, the need of drainage, may be another factor in realizing advantages from the application of scientific principles. Illustrations were drawn from German agriculture to show how favorable conditions have been a means of developing agriculture and of putting into practise the teachings of the experiment stations and other educational agencies. As an example, the use of fertilizers was

[1] SCIENCE, N. S., Vol. XLV., p. 149.

cited, which represents the application of science in determining the fertilizer needs and of education in their intelligent use.

Emphasis was laid on the importance of the true interpretation of science in practise, and attention was called to some of the factors which may upset the laboratory results and conclusions when they come to be applied. Hence broad generalizations from laboratory experiments under artificial conditions are to be made with great care. It is necessary to know not only the exact conditions under which the experiments were made, but the modifying character of various factors occurring in nature. The present confidence of the farmers in scientific work and their readiness to adopt suggestions makes it highly important that the teachings be sound from both a scientific and a practical standpoint.

In regard to "The Limitations of Science to Progress in Agriculture," Dr. Lipman mentioned first of all those inherent in investigators, which necessarily have the effect of retarding progress in acquiring knowledge and applying it in the field of agriculture. While contending that science itself knows no limitations, he agreed that there are many important phases of agricultural questions which have as yet eluded science because of the limitation to human ingenuity and ability to discover. Lack of vision is a most frequent deficiency; the outlook needs to be broadened as the problems become more intricate and technical. There needs also to be a quite thorough understanding of farm problems and of conditions surrounding the industry, so that the findings of science may be properly related to practise and practise may thereby be made scientific. Dr. Lipman strongly urged the adequate preparation of men for research in this field.

But apart from this, the greatest limitation of science in agriculture at present is in its application. This is due quite largely to lack of education of the average farmer. The man power is the real measure of efficiency of production, rather than the acre, and the increase of this measure means more education. To raise the level of production there must be a higher level of education among the mass of farmers. Economic conditions constitute another type of limitation in this connection. The scientific facts may be known beyond doubt, but owing to conditions the employment of these may for the time being be impractical and uneconomic.

Lack of working capital was mentioned as another very serious limitation to the application of science, which often hinders raising the level of production; and the same is true of lack of cooperation among producers, because single-handed the American farmer is often not able to fully utilize the findings of science or to take advantage of them as he might if broader areas and larger interests were concerned.

In considering "Economic Factors affecting the Application of Science to Agriculture," Dr. Warren maintained that when the attempt is made to apply the principles of natural science to industry no method is scientific that fails to count the cost. Because scientists sometimes fail to take full account of the economic aspects of agricultural problems, farmers criticize them as theorists, and because farmers refuse to follow their teachings scientists often criticize them for being unprogressive. It was held that while there is opportunity for improvement in agriculture as in all of the industries, "the erroneous but well-nigh universal idea of the city that science can easily double agricultural production leads to the most unfortunate public policies."

The effects of transportation, distance from market and special local conditions, were considered. Products which are easily and cheaply shipped may be produced long distances from market, while perishable products and those that are bulky are advantageously produced near market. For this reason the eastern dairyman is warranted in growing his hay and buying most of his grain, shipping his milk and butter to nearby cities. New York state is suited by climate and soil to the growth of sugar beets and efforts have been made to establish the industry there, but sugar can be shipped long distances, and near market it can not compete with bulky products, such as cabbages, potatoes and hay. Furthermore, it is not enough that a product pay; it must be part of the best paying system. Dr. Warren held that the farm practise of a region is usually found to be quite closely adapted to its economic conditions, and that in a long-settled agricultural region any effort to decidedly change the type of farming should be undertaken only after careful study of all the factors involved.

Some dangers to be avoided in the practical interpretation of experiments on fertilizers, feeding stuffs, etc., were illustrated, and some applications of the law of diminishing returns were made to broad generalizations from such experiments. The law of supply and demand also has an important bearing on the intensity of farm practise; and it was explained that the "two-blade of grass theory," first exploited as a means of doubling

the farmer's profits, has given way to a tendency toward the other extreme which holds that good crops are an injury to the farmer since they are usually accompanied by lower prices. Both extremes were declared erroneous. The conclusion was drawn that "agricultural practise is the resultant of many forces acting in as many different directions," all of which must be fully taken into account in prescribing rules for improvement.

In considering the subject of "Regional Conditions in Determining the Type of Agricultural Inquiry," Director Youngblood took for illustration the state of Texas, which is especially well adapted to the purpose. Within the state the variation in rainfall is from 8 to 55 inches, in elevation from sea level to approximately five thousand feet, in temperature from semi-tropical to strictly temperate, and in topography from flat to rough, while the soils of different localities are derived from various phases of at least ten geological periods. And apart from these physical differences the general character of the agriculture, the distance from market, and the intellectual status of the people all have to be taken into account in adjusting the agricultural inquiry to the needs of the locality.

The plan in Texas is adapted to these diverse conditions by means of a system of branch experiment stations located in typical agricultural areas and closely articulated with a central station at the agricultural college. In a sense these branch stations represent the industries of the locality and deal largely with practical questions, the plans for the experiments all being made with the advice of the experts at the central station, where a strong scientific basis is worked out on which to rest them. Director Youngblood laid emphasis on the endeavor to educate the people to the appreciation of all agricultural investigation, however simple or technical, and he expressed the conviction that even under the new and often transitional conditions in his state technical studies may be of the greatest practical value and may be made popular with the people.

In commenting on the papers in this symposium, Dr. Jordan drew the conclusion of the value of sound research and carefully guarded interpretation. He asserted that the experiment stations have been and are still putting too much time on mere variables that have no general significance, and too little on broad fundamentals. He also called attention to the fallacy and unwisdom of attempting to state the results of experiment in terms of dollars and cents—measures which have no real permanent or scientific significance.

Dr. L. H. Bailey referred to the difficulty in interpreting in the lives of the people and in public policy the results of agricultural investigation and inquiry; and he mentioned the desirability of a large and powerful organization which should bring its influence to bear in this direction, especially in expressing the voice of science in political matters and measures of public policy.

The officers elected for the coming year were as follows: *Vice-president*, Dr. H. J. Waters, president of the Kansas State Agricultural College; *Member of the Council*, President R. A. Pearson, of the Iowa State College; *Member of the General Committee*, Dr. J. G. Lipman, of the New Jersey Experiment Stations; *Member of the Sectional Committee* (for five years), Dean A. F. Woods, of the College of Agriculture, University of Minnesota.

E. W. Allen,
Secretary

SOCIETIES AND ACADEMIES

ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 506th meeting of the society was held in the Lecture Room of the Carnegie Library, on February 6. On this occasion Dr. J. Walter Fewkes, of the Bureau of American Ethnology, presented a paper on "Prehistoric Ruins of the Mesa Verde National Park," illustrated by lantern slides.

Dr. Fewkes described in detail the uncovering and repair of a large pueblo-like building in the Mesa Verde Park, near the ruin known as Sprucetree House. This work was accomplished by the speaker during the summer of 1916. The structure brought to light was 113 feet long by 100 feet wide, the ground plan showing the existence of four circular ceremonial rooms compactly embedded in fifty rectangular enclosures which were formerly used for secular purposes. From its wide southerly outlook this ruin has received the name of Far View House. It is the first pueblo habitation of this type ever found on the plateau.

After an extended consideration of the kiva or sacred room in its relation to pueblo architecture Dr. Fewkes described certain prehistoric kivas of the type generally called towers which he found in a canyon near Ouray, Utah. From their location on top of inverted cones of rock these were called by him Mushroom Rock ruins. The shape of these inverted cones of rock bore evidence to the enormous erosion which has occurred in this region.

Frances Densmore,
Secretary